

# Food and Nutrient Intake Differences between Smokers and Non-smokers in the US

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**Abstract:** Data from the Second National Health and Nutrition Examination Survey were analyzed to determine food and nutrient intake differences between current smokers (also categorized as light, moderate, and heavy smokers) and non-smokers. Smokers in several age-race-sex categories have lower intakes of vitamin C, folate, fiber, and vitamin A than non-smokers, and intake tended to decrease as cigarette consumption increased, particularly for vitamin C, fiber, and folate. Smokers were less likely to have consumed

vegetables, fruits (particularly fruits and vegetables high in vitamins C and A), high fiber grains, low fat milk, and vitamin and mineral supplements than non-smokers. A negative linear trend was found between smoking intensity and intake of several categories of fruits and vegetables. These data suggest that the high cancer risk associated with smoking is compounded by somewhat lower intake of nutrients and foods which are thought to be cancer protective. (*Am J Public Health* 1990; 80:1323-1329.)

## Introduction

Cigarette smoking is the biggest single health habit that contributes to preventable chronic disease in the United States especially cancer of the lung, larynx, oral cavity, and esophagus as well as coronary artery disease and emphysema.<sup>1</sup> Other cancers, such as bladder, kidney, pancreas, cervix, and stomach are also associated with cigarette consumption. Cigarette use in the US has been estimated to be a causative factor in 30 percent of all cancer deaths and in 87 percent of all lung cancer deaths.<sup>2</sup> It has also been estimated that diet is a causative factor in 35 percent (with a possible range of 10-70 percent) of all cancer deaths. While smoking, food, and alcohol consumption each are lifestyle practices associated with cancer risk, when they occur together some authors assert they act synergistically to produce risks which are greater than the sum of their parts.<sup>3</sup>

Compared to non-smokers, smokers consume more alcohol and coffee, take more risks, have more sexual partners, exercise less, sleep less, take vitamin and mineral supplements less, and skip breakfast more.<sup>4-11</sup> Furthermore, several of these poor health habits are more likely to occur with increasing average number of cigarettes smoked per day.<sup>8</sup>

Among smokers, those with either higher dietary intakes of vitamin and/or carotene or higher serum carotenoids are at reduced risk for lung cancer,<sup>12-25</sup> and several studies have examined the vitamin A, carotenoid, or energy intake differences between smokers and non-smokers.<sup>26-30</sup> A recent study showed an inverse association between intake of vitamin C and smoking.<sup>31</sup> Only one study<sup>32</sup> of 45-59 year old men enrolled in a prospective heart disease trial in Wales, however, examined total nutrient intake differences between smokers and non-smokers, and smokers were found to have lower intakes of most nutrients.

Understanding the dietary patterns of those who smoke compared to those who do not smoke is important for health professionals seeking to assess disease risk and educate individuals regarding healthy lifestyles. We used data from a large nationally representative survey, the Second National Health and Nutrition Examination Survey (NHANES II),<sup>33</sup> conducted from 1976-80, to determine whether smokers

significantly differ from non-smokers in both nutrient and food intake.

## Methods

NHANES II used a probability sample of the civilian non-institutionalized US population ages 6 months to 74 years. The complex sample design and sample weights are described in detail elsewhere.<sup>34</sup> Mobile examination centers employing trained teams of physicians, nurses, dietitians, and technicians traveled to and collected data from 64 sites throughout the country.

NHANES II 24-hour dietary recall data from 11,260 adults ages 19-74 years were used to assess dietary intake. For these analyses, races other than Black or White were excluded because of small sample sizes. Also excluded were individuals (N = 280) with imputed, surrogate, or unreliable 24-hours recall data. Trained interviewers collected dietary intake data from the day before the interview. Three-dimensional food portion models were used to help individuals accurately report portion sizes.<sup>35</sup> Dietary data were coded by the interviewers within 72 hours of data collection and analyzed for nutrient content using current nutrient values. Nutrient values for folate and dietary fiber, however, were not available on NHANES II tapes and were added later by Subar, *et al*,<sup>36</sup> and Lanza, *et al*,<sup>37</sup> respectively.

A smoking history was obtained from all subjects. Individuals were placed into categories of current, former, and never smokers, and current smokers were divided into categories of light, moderate, and heavy smokers based upon reported average use of 1-14, 15-24, or  $\geq 25$  cigarettes/day, respectively. Initial analyses showed few differences in nutrient or food intakes from 24-hour recall data between never and former smokers and therefore they were combined, creating a group of current non-smokers. Individuals who were not cigarette smokers but smoked either pipes (N = 63) or cigars (N = 140)  $< 6$ /week, and  $< 3$ /week, respectively, were included as non-smokers because usage was considered too infrequent to warrant exclusion. Frequent pipe or cigar users (N = 398) were excluded from the analyses.

Nutrient intake differences between current smokers and non-smokers, and among current non-smokers and light, moderate, and heavy smokers in the 24-hour recall data set were examined by race, sex, and broad age groups (19-29, 30-54, and 55-74 years). Differences in food intake were determined using food groups developed by Patterson and Block.<sup>38</sup> The food groups created were based upon the

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interim dietary guidelines by the National Research Council's report, *Diet, Nutrition and Cancer*,<sup>39</sup> and those of the American Cancer Society.<sup>40</sup> An inclusive "all vegetables" category was developed as well as the following vegetable subcategories: cruciferous vegetables (i.e. broccoli, cauliflower, brussels sprouts, cabbage), deep yellow vegetables (carrots, winter squash, sweet potatoes), fiber-rich vegetables (dried peas, beans, corn), and "garden vegetables" (all vegetables except white potatoes, dried peas and beans, and salad). Fruits and vegetables were also subdivided into categories of those high in either vitamin A (i.e. carrots, spinach, cantaloupe) or vitamin C (i.e. oranges, grapefruit, broccoli). A complete listing of foods in each category has been published.<sup>38</sup> Regardless of portion size or number of servings, individuals were described as having consumed or not consumed food(s) within each food group based upon 24-hour recall data. Preliminary analyses of food group intake indicated that such coding yielded few differences by sex and, therefore, individuals were categorized by age and race only.

In addition to univariate analyses described above, multivariate analyses of nutrient and food intake were performed adjusting for age, kcal/daily, poverty index ratio or PIR (an income status index which takes into account household income, family size, and the income necessary to maintain a family at the time the study was conducted), and sex. These analyses were performed separately for Whites and Blacks because of the known racial differences in consumption of foods and nutrients.<sup>41</sup>

Separate analyses by sex-race categories were performed to determine whether smoking category based upon average daily cigarette consumption, as measured in half packs of cigarettes consumed, was linearly related to intake of nutrients or food groups. Each nutrient or food group, acting as a dependent variable in the model which adjusted for age, examined the effect of half packs of cigarettes consumed. For purposes of these analyses, quartiles of nutrient intake by race-sex groups were used.

Statistical analyses were performed using SAS<sup>42</sup> with appropriate population weights permitting inferences about the total adult US Black and White population. Standard

errors were calculated using SESUDAAN,<sup>43</sup> a program designed to account for the complex survey design. The SURREGR<sup>44</sup> program for complex samples was used in multivariate analysis for the White population, but because of the lack of dispersion of Blacks throughout strata and primary sampling units (PSU), an unweighted regression analysis was used for Blacks. Logistic regressions were performed using the RTIlogit program.<sup>45</sup> This application uses the Taylor expansion series to estimate the variances.

## Results

### Food Group Intake Differences

Analyses by age, race, sex, and current smoking status showed a larger proportion of Black men (55 percent) smoked during the period of the NHANES II study than in any other sex-race category, followed by White men (43 percent), White women (34 percent), and Black women (34 percent). In all age-race-sex groups, approximately 50 percent of all smokers are 30–54 years of age, while approximately one-third and 15 percent are ages 19–29 and 55–74 years, respectively.

Tables 1 and 2 present univariate analyses of food group intake of smokers and non-smokers by age for Whites and Blacks, respectively. With few exceptions, intake of vegetable categories except "starchy fibrous" is moderately higher among non-smokers as compared to smokers in all age-race groups. Multivariate analyses which adjusted for age, kcal/day, PIR, and sex confirmed these results among Whites. Both univariate and multivariate analyses show that non-smokers of both races have a strikingly higher intake of fruits compared to smokers with percentage differences as high as 19 percent (unadjusted) for 19–29 and 30–54 year old Whites, and 55–74 year old Blacks. For the categories of high fiber grains and fruits or vegetables high in either vitamin C or vitamin A, non-smokers in all age-race categories have a greater intake than smokers, a finding confirmed after multivariate adjustment. For high fiber grains, however, it should be noted that Blacks have much lower intakes than Whites with the highest intakes among Black non-smokers equal to or less than the lowest intakes of White smokers.

TABLE 1—Weighted Percent of White Subjects Consuming Food(s) Over a 24-Hour Period (NHANES II) by Age and Smoking Status

Food Group	Whites 19–29 years				Whites 30–54 years				Whites 55–74 years			
	Non-Smoker	95% CI <sup>a</sup>	Smoker	95% CI	Non-Smoker	95% CI	Smoker	95% CI	Non-Smoker	95% CI	Smoker	95% CI
All Vegetables	84.4	82.6,86.1	79.0	76.7,81.3	85.9	84.4,87.4	81.0	79.2,82.9	86.3	84.7,87.9	82.9	79.9,86.0
Garden	49.7	47.0,52.4	42.7	39.3,46.1	54.2	51.4,57.0	48.5	46.4,50.5	58.4	55.9,61.0	51.9	48.3,55.5
Deep Yellow	9.2	7.4,11.1	6.3	4.4,8.1	11.6	9.8,13.4	8.7	6.8,10.6	13.7	12.2,15.2	11.0	8.8,13.2
Cruciferous	15.3	13.4,17.2	12.0	9.9,14.1	20.0	18.5,21.5	15.9	13.4,18.3	21.2	19.3,23.0	18.4	16.3,20.4
Starchy Fibrous	18.8	16.0,21.5	18.8	15.9,21.7	19.1	17.2,21.1	18.2	16.2,20.2	18.0	15.4,20.5	17.9	15.2,20.6
Salad	48.6	45.3,52.0	39.4	35.7,43.0	50.5	48.4,52.6	46.7	43.6,49.9	49.7	47.3,52.1	46.1	42.4,49.8
All Fruits	59.3	56.4,62.3	39.6	35.7,43.5	63.9	61.7,66.1	45.4	42.4,48.5	76.8	74.8,78.7	63.3	60.0,66.5
Fruits/Vegetables												
High in Vitamin A	18.4	15.7,21.1	13.3	11.5,15.1	23.2	21.2,25.2	15.9	13.8,18.1	26.1	24.1,28.1	20.8	17.9,23.7
High in Vitamin C	25.6	22.5,28.7	19.5	16.7,22.3	31.6	29.2,34.1	20.4	17.9,22.9	36.5	33.2,39.7	27.6	24.1,31.1
High Fiber Grains	16.6	13.1,20.0	9.9	6.8,12.9	18.1	15.4,20.9	11.1	8.4,13.7	25.5	23.1,27.9	20.0	16.1,23.8
Red Meat	59.5	56.4,62.6	60.5	57.5,63.4	56.0	53.8,58.3	56.8	54.1,59.5	50.2	48.2,52.1	50.1	46.1,54.1
Poultry/Fish	31.8	29.0,34.6	29.3	26.7,31.9	33.0	30.5,35.5	28.7	25.7,31.8	34.8	32.6,37.1	30.4	26.8,33.9
Bacon/Luncheon												
Meat	36.2	33.6,38.9	41.2	37.6,44.7	42.4	39.6,45.2	46.6	43.1,50.0	41.4	38.6,44.2	44.9	40.9,49.0
Whole Milk	41.8	38.5,45.0	47.6	43.7,51.4	40.5	37.8,43.1	43.3	39.7,46.9	39.6	36.7,42.6	46.0	41.8,50.3
Low Fat Milk	30.2	26.2,34.3	22.0	18.1,25.8	28.7	25.9,31.6	20.3	17.0,23.7	34.5	31.7,37.4	24.2	20.2,28.3
Use Supplements <sup>b</sup>	24.3	22.0,26.6	15.6	13.3,17.9	24.9	22.4,27.3	20.8	18.0,23.6	34.6	32.1,37.1	29.3	25.9,32.8

a) CI = Confidence interval.

b) Data based upon reported "regular" usage of vitamin/mineral supplements.

TABLE 2—Weighted Percent of Black Subjects Consuming Food(s) Over a 24-Hour Period (NHANES II) by Age and Smoking Status

Food Group	Blacks 19–29 years				Blacks 30–54 years				Blacks 55–74 years			
	Non-Smoker	95% CI <sup>a</sup>	Smoker	95% CI	Non-Smoker	95% CI	Smoker	95% CI	Non-Smoker	95% CI	Smoker	95% CI
All Vegetables	77.5	69.4,85.6	79.6	72.2,87.0	77.8	72.2,83.4	70.6	63.1,78.1	80.2	74.2,86.1	70.6	62.5,78.6
Garden	43.8	34.3,53.3	42.1	33.3,50.9	52.5	41.8,63.3	41.2	33.1,49.3	58.6	50.1,67.1	43.6	34.9,52.4
Deep Yellow	6.3	2.6,9.9	6.4	2.4,10.4	8.7	2.3,15.0	7.4	4.0,10.8	17.8	12.8,22.8	6.5	3.0,10.1
Cruciferous	21.1	12.5,29.7	18.9	12.0,25.9	23.7	13.4,33.9	21.3	15.1,27.5	28.4	20.7,36.2	22.6	11.8,33.4
Starchy Fibrous	22.5	18.3,26.7	18.3	11.4,25.3	17.6	12.7,22.5	13.2	8.5,17.9	18.8	11.0,26.5	27.0	17.8,36.2
Salad	34.5	27.7,41.3	25.7	18.7,32.6	26.7	19.8,33.7	26.4	21.5,31.4	25.1	17.7,32.5	17.1	9.6,24.6
All Fruits	62.0	54.4,69.5	47.8	38.0,57.5	61.2	53.4,69.0	49.2	40.6,57.8	64.0	56.0,72.0	45.3	37.2,53.5
Fruits/Vegetables												
High in Vitamin A	21.6	13.6,29.7	19.3	12.4,26.2	26.2	16.1,36.2	25.0	17.6,32.4	38.6	30.9,46.3	22.7	12.2,33.2
High in Vitamin C	34.7	26.9,42.6	30.7	23.8,37.6	33.5	25.3,41.6	29.7	23.9,35.5	44.7	35.3,54.0	32.7	22.6,42.8
High Fiber Grains	8.9	5.0,12.8	4.9	1.6,8.2	11.6	6.5,16.6	6.4	3.0,9.8	10.9	6.9,14.8	5.8	0.0*,11.9
Red Meat	58.2	49.6,66.8	56.3	49.7,62.8	44.8	38.8,50.8	45.9	38.4,53.4	35.6	28.7,42.4	35.1	27.2,42.9
Poultry/Fish	47.4	36.5,58.4	41.2	31.7,50.7	55.3	48.5,62.1	48.2	40.3,56.2	52.2	44.4,60.1	47.8	36.0,59.5
Bacon/Luncheon Meat	40.4	34.5,46.2	47.8	37.1,58.6	41.8	35.6,48.0	48.2	41.3,55.2	45.7	39.6,51.9	52.8	43.8,61.8
Whole Milk	41.4	34.8,48.1	35.0	28.2,41.7	27.1	18.0,36.2	32.9	24.6,41.2	33.8	24.7,42.9	33.6	24.4,42.8
Low-Fat Milk	3.5	0.3,6.8	2.7	0.3,5.2	18.7	11.9,25.5	4.5	1.1,7.9	15.7	9.1,22.3	10.2	4.3,16.0
Use Supplements <sup>b</sup>	13.3	8.9,17.7	13.6	7.9,19.2	23.8	16.3,31.3	12.4	8.5,16.3	2.0	14.5,25.5	16.6	9.1,24.0

a) CI = Confidence interval.

b) Data based upon reported "regular" usage of vitamin/mineral supplements.

\*Lower limit truncated to 0.0 from a negative value.

Univariate analyses (Tables 1 and 2) showed that non-smokers compared to smokers tended to consume equal amounts of red meat, but more poultry/fish and skim milk, and less bacon/luncheon meats, and whole milk. These findings were confirmed in the multivariate model. In addition, among Whites and most Blacks, non-smokers were more likely to take vitamin/mineral supplements. Blacks, however, were low supplement users overall.

#### Nutrient Intake Differences

Tables 3 and 4 present, for Whites and Blacks, respectively, univariate analyses of mean intake data for energy, seven nutrients, dietary fiber, and cholesterol by age, sex, and current smoking status. Analyses were also performed for calcium, iron, thiamin, riboflavin, niacin, oleic acid, and linoleic acid, but results showed few or no differences by smoking status (data available upon request to author). As found in past research of the NHANES II data set,<sup>27</sup> smokers tended to consume more kcal than non-smokers. Few intake differences between smokers and non-smokers were found with respect to fat, protein, carbohydrate, and cholesterol.

Mean vitamin C intake is higher among non-smokers in all age-race-sex categories (Tables 3 and 4) with the difference being most striking among White males. After controlling for age, kcal, PIR, and sex, a negative association remained between smoking and vitamin C consumption for both races.

Univariate analyses of vitamin A intake are inconsistent among age-sex-race categories with non-smokers consuming greater or equal amounts compared to smokers. In multivariate analysis, however, a negative association was found between smoking and vitamin A intake among Whites.

With the exception of older Black males, there is a tendency among all age-race-sex groups for smokers to consume less folate and dietary fiber than non-smokers (Tables 3 and 4). After adjustment, these results were confirmed for dietary fiber in both Blacks and Whites and for folate in Whites only.

#### Linear Trends in Nutrient and Food Intake

Using multiple linear regression, nutrient intake was examined for a linear relationship between sex-specific quintile of nutrient intake and cigarette consumption, as measured in half packs of cigarettes consumed. No trends were found among Blacks for any food or nutrients after adjusting for age. In Whites, after adjusting for age, negative associations between cigarette consumption and both vitamins C and A were found for males ( $\beta = -0.11$  s.e. = 0.015,  $\beta = -0.06$  s.e. = 0.012, respectively) and females ( $\beta = -0.14$  s.e. = 0.014,  $\beta = -0.08$  s.e. = 0.014, respectively). Similar negative associations were found for folate among males ( $\beta = -0.06$  s.e. = 0.014) and females ( $\beta = -0.09$  s.e. = 0.017) and for dietary fiber among males ( $\beta = -0.09$  s.e. = 0.015) and females ( $\beta = -0.11$  s.e. = 0.017). A positive association was found between cigarette consumption and intake of saturated fatty acids for males ( $\beta = 0.04$  s.e. = 0.013).

For food group intake adjusted for age, a negative linear trend existed between increasing cigarette consumption and intake of any vegetable (males  $\beta = -0.10$  s.e. = 0.028 and females  $\beta = -0.10$  s.e. = 0.029), garden vegetables (males  $\beta = -0.09$  s.e. = 0.020 and females  $\beta = -0.10$  s.e. = 0.027), any fruit (males  $\beta = -0.22$  s.e. = 0.027 and females  $\beta = -0.34$  s.e. = 0.030), fruits or vegetables high in vitamin A (males  $\beta = -0.13$  s.e. = 0.035 and females  $\beta = -0.18$  s.e. = 0.045), fruits or vegetables high in vitamin C (males  $\beta = -0.21$  s.e. = 0.031 and females  $\beta = -0.19$  s.e. = 0.035), high fiber grains (males  $\beta = -0.23$  s.e. = 0.038 and females  $\beta = -0.15$  s.e. = 0.048), low fat milk (males  $\beta = -0.17$  s.e. = 0.025 and females  $\beta = -0.22$  s.e. = 0.040), and vitamin and mineral supplements among all Whites. In White males a negative association was found between increasing consumption of cigarettes and salad ( $\beta = -0.08$  s.e. = 0.018), any cruciferous vegetable ( $\beta = -0.09$  s.e. = 0.032), and poultry and fish ( $\beta = -0.07$  s.e. = 0.023).

#### Discussion

Several limitations of this study should be mentioned. Twenty-four recalls are considered suitable for the study of

TABLE 3—Weighted Mean Nutrient Intake for White Subjects from NHANES II 24-Hour Recall Data by Sex and Smoking Status

Nutrient	White Men				White Women			
	Non-Smoker	95% CI <sup>a</sup>	Smoker	95% CI	Non-Smoker	95% CI	Smoker	95% CI
<i>Ages 19–29 years</i>								
Energy kcal	2947	2790,3105	2997	2868,3127	1667	1614,1720	1679	1603,1755
Protein g	118	112,125	112	107,118	66	64,68	61	57,66
Carbohydrate g	315	300,330	313	297,330	193	186,200	191	182,201
Fat g	122	114,129	118	111,125	68	66,71	66	63,70
Saturated fat g	44	41,47	44	42,47	24	23,25	24	22,25
Cholesterol mg	463	422,505	448	417,479	268	252,284	251	226,275
Vitamin A IU	6000	5368,6631	4529	4155,4903	4582	4156,5007	3810	3142,4477
Vitamin C mg	135	120,150	97	86,108	96	88,104	86	74,98
Folate µg	349	326,372	307	285,330	212	201,223	182	167,198
Fiber g	14.7	13.6,15.7	12.4	11.4,13.4	9.8	9.1,10.5	8.2	7.6,8.8
<i>Ages 30–54 years</i>								
Energy kcal	2444	2340,2548	2569	2493,2645	1535	1488,1582	1591	1542,1641
Protein g	97	93,101	99	96,102	62	60,65	60	58,63
Carbohydrate g	261	248,275	261	254,269	173	168,178	169	163,175
Fat g	102	98,107	108	104,112	63	61,66	68	65,70
Saturated fat g	37	35,39	40	38,41	22	21,23	24	23,25
Cholesterol mg	441	412,469	453	424,482	284	265,302	297	276,318
Vitamin A IU	5796	5112,6480	5926	4854,6997	5567	4726,6409	4204	3676,4732
Vitamin C mg	110	103,117	88	80,95	103	95,111	70	63,76
Folate µg	287	270,305	274	256,292	216	203,229	184	171,198
Fiber g	13.9	13.0,14.7	12.2	11.3,13.1	10.2	9.7,10.6	8.2	7.8,8.6
<i>Ages 55–74 years</i>								
Energy kcal	1998	1955,2042	2010	1942,2078	1360	1329,1391	1390	1336,1445
Protein g	81	79,83	78	75,82	54	52,55	54	51,57
Carbohydrate g	218	212,224	208	199,217	163	158,167	154	146,161
Fat g	82	79,85	85	81,89	54	52,55	57	54,60
Saturated fat g	29	28,30	31	30,33	18	18,19	20	19,21
Cholesterol mg	396	374,418	433	410,456	252	242,262	255	239,272
Vitamin A IU	6320	5824,6816	5990	5278,6702	5426	5000,5851	5225	4575,5874
Vitamin C mg	111	104,118	88	79,97	109	103,115	93	81,105
Folate µg	281	269,293	255	237,272	217	209,224	200	187,213
Fiber g	13.1	12.5,13.7	11.9	11.0,12.9	10.8	10.6,11.1	9.1	8.5,9.8

a) CI = Confidence interval.

group but not individual means.<sup>46</sup> At least one investigator, however, has suggested that the bias due to reporting error inherent in the method may be greater than the difference detected between groups.<sup>47</sup> Given the large size and scope of NHANES II, the 24-hour recall data are likely to be appropriate for the group analysis presented here, but should be viewed with caution because of potential bias. In particular, conclusions regarding nutrients known to have large variability (such as vitamin A) may be subject to question when small groups are examined.<sup>47</sup> Because the number of Blacks sampled in NHANES II is relatively small in comparison to Whites, the results for Blacks cannot be viewed with the same degree of confidence. Finally, the coding of intake of food groups which is based upon mentions from the recalls yields no information regarding portion size and, therefore, is useful but imprecise quantitatively.

Smoking and diet are among the top 10 risk factors thought to cause the majority of disease in the US.<sup>48</sup> Our findings suggest that there are important dietary differences between smokers and non-smokers, all tending toward unhealthy patterns. Surprisingly few differences by current smoking status were found for fat, saturated fat, and cholesterol, dietary variables associated with coronary heart disease. Smokers did, however, consume less poultry/fish and low fat milk and more whole milk and luncheon meats than non-smokers. With respect to cancer prevention, however,

there is interest not only in the role of fat, but also in the roles of fruits, vegetables, fiber, vitamin A/carotenoids, vitamin C, and folate. For all these foods or dietary constituents, we found that smokers, in general, consume less than non-smokers, with vitamin C/fruit intake showing the greatest and most consistent difference across all age-sex-race groups.

Our findings with respect to vitamin C and fruits are intriguing for several reasons. First, vitamin C is thought to protect against cancer through reduction functions which serve to both prevent carcinogens from forming and decrease the carcinogenic effects of certain chemical agents and through the enhancement of host resistance.<sup>49</sup> Second, several studies have shown that smokers have lower serum vitamin C levels than non-smokers, and that vitamin C turnover in smokers is higher than in non-smokers.<sup>31,50–52</sup> Several investigators have suggested, therefore, that smokers have increased vitamin C requirements. While mean vitamin C intake data suggest that smokers are meeting their Recommended Dietary Allowance (RDA) for vitamin C (60 mg),<sup>53</sup> this level may not be high enough to counteract the increased vitamin C turnover resulting from their smoking habit. Our data suggest that this very group, which requires more vitamin C, is consuming significantly less. While we do not account for vitamin C intake from supplements, the data show that smokers are less likely to be taking supplements than non-smokers. Third, our vitamin C and fruit results are

TABLE 4—Weighted Mean Nutrient Intake for Black Subjects from NHANES II 24-Hour Recall Data by Sex and Smoking Status

Nutrient	Black Men				Black Women			
	Non-Smoker	95% CI <sup>a</sup>	Smoker	95% CI	Non-Smoker	95% CI	Smoker	95% CI
<b>Ages 19–29 years</b>								
Energy kcal	2603	2247,2958	2796	2348,3244	1715	1576,1855	1731	1573,1889
Protein g	102	88,116	110	76,145	67	62,72	61	55,67
Carbohydrate g	281	241,320	281	253,308	202	176,227	211	187,235
Fat g	110	91,129	114	87,140	71	67,76	67	61,74
Saturated fat g	38	31,44	42	30,54	25	23,28	23	20,26
Cholesterol mg	487	396,578	547	360,735	321	269,372	341	298,383
Vitamin A IU	7973	2410,13536	6530	4701,8358	3923	3306,4539	3987	2829,5145
Vitamin C mg	129	98,160	113	89,138	108	79,136	107	84,130
Folate µg	302	248,356	247	219,274	194	160,227	188	156,220
Fiber g	12.8	10.4,15.2	10.2	8.9,11.5	8.3	7.3,9.3	7.7	6.4,9.0
<b>Ages 30–54 years</b>								
Energy kcal	2006	1784,2228	2369	2140,2598	1391	1268,1514	1328	1239,1418
Protein g	81	70,92	88	81,95	55	50,59	52	47,58
Carbohydrate g	223	204,242	229	209,249	159	143,176	145	129,160
Fat g	82	70,94	93	80,106	57	51,63	56	49,62
Saturated fat g	28	24,33	33	28,39	20	17,22	19	17,21
Cholesterol mg	514	373,655	472	411,533	291	252,331	305	262,349
Vitamin A IU	10204*	6004,14405	4943	3225,6661	4503	3528,5478	6008	4498,7518
Vitamin C mg	133	89,177	104	74,133	96	76,116	71	59,82
Folate µg	264	208,319	213	195,232	173	153,193	155	140,170
Fiber g	12.7	10.3,15.1	9.3	8.4,10.4	7.5	6.8,8.2	7.2	5.9,8.5
<b>Ages 55–74 years</b>								
Energy kcal	1751	1579,1924	1764	1617,1912	1255	1167,1343	1341	1158,1524
Protein g	69	62,76	68	62,75	51	47,54	55	45,64
Carbohydrate g	191	168,214	177	161,193	150	138,162	158	141,176
Fat g	71	63,80	73	64,83	50	45,55	53	45,64
Saturated fat g	25	22,29	27	23,30	17	15,19	18	15,22
Cholesterol mg	378	342,415	420	363,477	273	231,315	261	206,317
Vitamin A IU	6727	4632,8821	5591	4048,7134	7667	5592,9741	4718	2430,7006
Vitamin C mg	98	76,121	79	62,95	114	100,129	105	61,150
Folate µg	216	186,246	241	190,292	190	156,223	175	143,208
Fiber g	11.8	9.8,13.9	10.1	7.8,12.5	9.0	7.9,10.1	9.4	7.9,10.9

a) CI = Confidence interval.

\*High value due to 3 individuals with unusually large intakes of liver and/or eggs and/or carrots.

consistent with research suggesting that smoking (via nicotine) decreases the desire for sweet foods and in particular, fruit juices.<sup>54,55</sup> While our results may, in part, be explained by taste preference characteristics due to the metabolic effects of nicotine, this does not resolve the differences found between smokers and non-smokers in their intake of other non-sweet foods.

High intakes of dietary fiber are suspected to be a preventive factor in colon cancer,<sup>56</sup> and the National Cancer Institute recommends that individuals consume 20–30 gm of dietary fiber daily.<sup>57</sup> Past research based on NHANES II data shows that intake of dietary fiber in the US is much lower than this recommendation,<sup>37</sup> and we show that smokers have among the lowest intakes. While tobacco use is not known to be related to bowel cancer, our results suggest that smokers could be at higher risk for this cancer through related dietary lifestyle habits. Furthermore, our results indicate that this lower intake results from lower consumption of several key sources<sup>58</sup> of dietary fiber: vegetables, whole grains, and fruits.

Consistent with past research,<sup>30,32</sup> we found that smokers have, for the most part, lower intakes of vitamin A than non-smokers. While smokers have 25 times the risk of developing lung cancer compared to non-smokers, both low dietary intake and serum vitamin A and/or carotenoids have

been shown to increase smoking adjusted lung cancer risk in the range of 1.3 to 2.7 times.<sup>13,14,16,19–25</sup> Furthermore, several studies have shown that low dietary or serum vitamin A/carotenoid levels increase lung cancer risk (range: 1.3–8.1) among smokers, including the heaviest and those who have smoked the longest.<sup>12,16,18,20,22,24,25</sup> Evidence of dietary protection is strongest for carotenoids (from plants) versus retinol sources (from animals).<sup>59</sup> A separate measure of the carotenoid or retinol composition of foods was not available in our database, but our finding that smokers consume fewer fruits or vegetables high in vitamin A, and fewer fruits and vegetables overall, suggest that smokers have lower carotenoid intakes than non-smokers. Stryker, *et al.*,<sup>28</sup> have suggested that smokers need to increase their intake of carotenoids to achieve blood levels comparable to their non-smoking counterparts. Our results show that smokers, who may gain some protection from lung cancer by high carotenoid intake, are less likely than non-smokers to be consuming carotenoid-dense foods. Furthermore, former smokers, who enjoy gradually declining lung cancer risk, should be encouraged toward improved nutrition in an effort to possibly accelerate the decline.

A few reports have suggested that folate may be protective for both lung and cervical cancer.<sup>60–62</sup> While our results with respect to intake differences between smokers

and non-smokers are less striking for folate than for vitamin C, such differences should be noted in that they fit into a general pattern of lower intake of fruits, vegetables and high fiber grains among smokers.

Questions remain as to whether specific dietary factors such as vitamin A, carotenoids, and vitamin C are the operative cancer protective factors in foods or whether some other yet unknown factor(s) is responsible. Studies have shown that intake of cruciferous vegetables, fruits and vegetables, and especially yellow-orange and green vegetables have protective effects not only for lung cancer, but also for breast, colon, prostate, bladder, oral cavity, stomach and cervical cancers.<sup>56</sup> Our results show that intake of all these foods is significantly lower among smokers. This suggests that smokers may be at higher risk for many cancers, some of which are non-smoking-related. Of particular interest is our finding that for several of the cancer protective food groups, there are modest but consistent trends for intake to decrease as cigarette consumption increases. Thus, the more one tends to smoke, the more one increases cancer risk, the less one tends to consume fruits, vegetables, and high fiber grains. These findings are similar to that of Schoenborn and Benson<sup>8</sup> regarding other lifestyle factors such as sleeping less than six hours per night, skipping breakfast, being less physically active, being sedentary, and drinking heavily.

One possible explanation for lower intakes of nutrients and some foods among smokers may be that smokers compared to non-smokers tend to be greater consumers of alcoholic beverages<sup>5</sup> and, therefore, may replace calories and nutrients from food sources with those from drinks. Because we had no data regarding the contribution of alcohol to either the caloric or carbohydrate content of the 24-hour recalls we analyzed, we were not able to explore this possibility, and past research yields conflicting results.<sup>29,63</sup> Further research is necessary to determine whether alcohol consumption plays a significant role in the lower intake of nutrients and foods found among smokers in this research.

Our findings of lower intakes of vitamin A, vitamin C, fiber, and folate among smokers are correlated in that all these nutrients are common to vegetables, fruits, and grains, foods for which we also found lower consumption among smokers. The task of understanding how nutrients and/or foods protect or promote cancer while considering other risk factors such as smoking is difficult. We have shown that smokers, who are known to be at increased risk for several cancers, have lower intake of nutrients and foods associated with cancer prevention than non-smokers. The evidence is clear that smoking is a habit which leads to or is lead by other lifestyle practices, and we have shown that yet another important health habit is associated with smoking: food intake. This suggests that analyses in future epidemiological research regarding cancer prevention or etiology account for the possible confounding of smoking and diet.

Smoking cessation is the single biggest prevention measure for purposes of cancer prevention and control, particularly with respect to lung cancer.<sup>2</sup> Individuals who smoke are clearly at greatly increased risk from their tobacco use. However, this study suggests that they may be at some slightly additional risk from dietary intake low in critical nutrients. While more research is needed regarding smoking and diet, smokers and ex-smokers may be well advised to increase their intake of fruits, vegetables, and high fiber grains. In the meantime, physicians and the public should be aware that some smokers have low intakes of foods or nutrients associated with decreased cancer risk.

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